Electrostatic Separation of Lunar Regolith for Size Beneficiation Using Same-Material Tribocharging

Completed Technology Project (2015 - 2019)

Project Introduction

The success of future long-term manned lunar missions depends on the development of certain key technologies. One such technology, the utilization of lunar regolith for the construction of parts and structures, is one of the most significant factors in reducing mission cost, risk, and complexity. Current research on this topic focuses on 3D printing techniques using regolith and other advanced fabrication methods. In order to create strong, reliable parts, the mineral composition and granular size of the regolith must be tightly controlled. Though many terrestrial devices exist for sorting granular materials by size and material, like sieves and centrifuges, many of these are large, complex, or ineffective in the low-gravity, highly electrical lunar environment. Furthermore, the lunar surface is highly electrically charged, posing risks of discharge and significant clumping in many regolith-handling devices. Therefore, a novel device for size beneficiation of lunar grains which removes or utilizes this charge will be necessary to advance the development of resource utilization technologies and improve future exploration missions. Tribocharging shows great promise as a method for both size beneficiation and mineral separation, and I propose to develop a device using this phenomenon for lunar regolith. When a granular mixture is shaken, the triboelectric effect causes charge to accumulate on particular minerals in the mixture in a predictable way. A far less understood aspect of the triboelectric effect is the tendency for negative charge to also accumulate on smaller grains, even when the mixture is composed of only one insulating material. While mineral separation using tribocharging has been demonstrated successfully, no space-ready device yet exists to take advantage of the size-dependent charging effect. I will design, build, and test such a device. I will first develop an underlying theory for same-material, size-dependent tribocharging through experiments. This theory will be applied to lunar regolith, a complex and disperse mixture of many materials and sizes. The device will use electrostatic separation of tribocharged grains to sort the material with minimal moving parts or contact with the grains. Due to the highly adhesive and abrasive nature of lunar regolith, this significantly increases the lifespan of the device and reduces its complexity relative to other grain separation concepts. In addition, the existing charge on lunar grains reduces the effectiveness of other existing separation methods, but is a boon to an electrostatic separation device. The results of my experiments will reveal the effects of various pre- and post-treatment methods on tribocharging of regolith, which I can use to increase the degree of size separation and remove the charge after separation. Therefore, the device would take raw charged regolith as input, and produce electrically neutral grains sorted by mineral and/or size, depending on the desired mode of operation. Electrostatic size beneficiation using tribocharging is still a very young field, but shows promise for low-complexity regolith separation. The lack of understanding of this effect has limited its use in grain sorting applications to date. Given the recent push for better in situ resource utilization, and the advancements in 3D printing technologies, there is a growing need for a device to convert regolith into a

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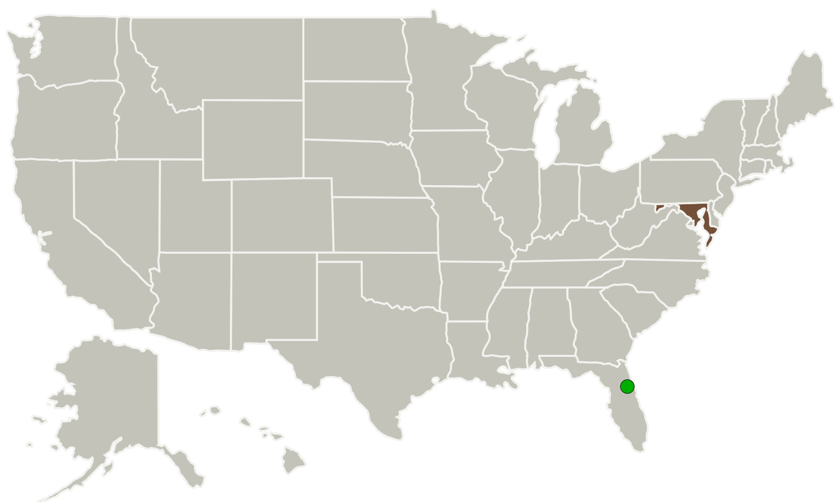
Anticipated Benefits

Given the recent push for better in situ resource utilization, and the advancements in 3D printing technologies, there is a growing need for a device to convert regolith into a usable raw material. My proposed solution is simple, reliable, and flexible, and provides a design heritage for grain separators in other environments due to the universality of tribocharging. Developing this technology is a critical and innovative step toward exploration of any dusty celestial body.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Maryland-College Park (UMCP)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Christine Hartzell

Co-Investigator:

Dylan Carter

Organizations Performing Work	Role	Type	Location
University of Maryland-College Park(UMCP)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	College Park, Maryland
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida

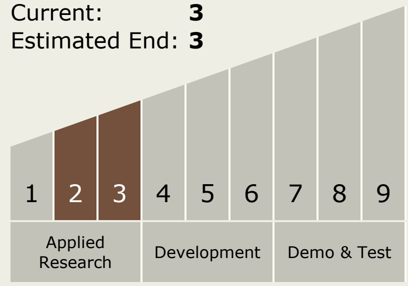
Primary U.S. Work Locations
Maryland

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  └ TX07.1 In-Situ Resource Utilization
    └ TX07.1.2 Resource Acquisition, Isolation, and Preparation

Target Destinations

The Moon, Mars, Others Inside the Solar System